6

REPORT

ON

DENTAL HISTOLOGY

AND

MICROSCOPY.

BY

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Illustrated by Copies of Original Photo-Micrographs, by the Heliotype process.

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REPORT.

THE facts shown by Kölliker, in regard to the development of the teeth of ruminants, were shown by Waldeyer, as early as 1865, to be true also with reference to the development of the human teeth. They proved the observations of Arnold and Goodsir in regard to the teeth papillæ rising from an open dental groove to be incorrect.

The first indication toward the formation of a tooth is seen in a fold of the oral epithelium, which projects into the jaw, and, expanding, gradually takes the shape of the enamel cap of the tooth. The fold of epithelium is doubled upon itself, and it is the inner layer, internal epithelium, in which the enamel cells are developed. Shortly after the dipping down of the epithelium, and before it has expanded, there occurs a proliferation of cells just below, which under a low power of the microscope presents a darker appearance. This is the first rudiment of the dental germ or pulp. As development proceeds, this appearance becomes more marked, and the tissue assumes the shape of the dentine of the tooth which it represents. (Plates I. and II.)

The oral epithelium covers the surface of the dentinal germ, the space between the folds being filled with cells. The cells of the internal epithelium, next the dentinal pulp, become lengthened, are supplied with numerous nuclei, and finally assume the shape of the well-known cells of the enamel organ. (Plates III. and IV.)

The cells forming the dentinal germ or pulp, which at first were irregularly situated in their blastema, have become nearest the surface larger, and lengthened; have one or more nuclei, and after dentification has commenced, present the prolongations extending into the formed dentine, which we call dentinal fibrils. (Plate V.)

The cells or odontoblasts have, beside this process, to which Waldeyer has given the name of dentinal process, others, which he

calls the pulp process and the lateral process, and which extend inwards, toward the centre of the pulp, and laterally, communicating with other odontoblasts and reparative cells. Sometimes there are as many as six of these processes from a single odontoblast.

Observers are not agreed with reference to the termination of the dentinal tubes.

Wedl is inclined to think that they form by their anastomoses an inclosed system. The line of junction of the enamel and dentine is generally well marked, the dentinal tubes not extending into the enamel. Mr. J. Tomes, however, says some of the tubes pass across the line of junction into the enamel. Kölliker holds the same opinion, as also does Mr. C. S. Tomes.

Hertz and Waldeyer, however, inasmuch as they have been unable to verify these observations, differ from them, the latter saying a direct passage of the dentinal tubes into the enamel does not occur.

Examination of Plate VI. seems to prove that at times the dentinal tubes do penetrate the enamel, and that to a considerable depth. Physiologically, may not this account for the extreme sensitiveness which we sometimes find in the enamel while preparing cavities for filling?

With reference to the ultimate distribution of the nerves of the pulp, no new investigations have been recorded during the past year. The investigations of Dr. F. Boll in 1868, who was able, in the teeth of rabbits, to trace certain fine pale fibres, which were side by side with the dentinal fibres, and which he therefore believed entered the dentinal tubes, till he found them continuous with medullated nerve fibres, have been verified by others, and are received by many histologists.

Czermack first described the interglobular spaces. In examining for them Mr. C. S. Tomes tells us that they will be much more readily seen if the teeth from which sections are cut have been first boiled in wax. They are found in nearly all teeth, and are not confined to the teeth of man. Mr. C. S. Tomes says they sometimes are obliterated by undergoing calcification, when the appearance described as "areolar dentine" is seen. (Plate VII.)

Waldeyer says they "are the result of a somewhat irregular process of dentification."

Prof. Wedl holds the same opinion. The latter states also,

that sometimes in the teeth of elderly persons there is seen an increase in the number and size of the interglobular spaces, that they are often filled with amorphous calcareous salts, and that they are occasioned by interstitial absorption of the dentine.

The publication of English editions of Wedl's "Pathology of the Teeth," and Leber and Rottenstein on "Dental Caries," and a second edition of Tomes' "Dental Surgery" during the past year, has furnished us with several new observations in regard to the theory of dental caries. These are based upon the microscopical appearances presented as the result in many experiments, not only upon living teeth, but upon reinserted human teeth and teeth made from ivory.

Mr. J. Tomes and Dr. E. Magitot supposed the translucent zone of dentine in advance of caries was the result of a vital process, a consolidation of the dentinal tubuli, whereby the tissue was rendered more dense, and therefore less readily acted upon by the agents producing caries. It has, however, been shown by Leber and Rottenstein that this change occurs in human teeth which have been inserted as artificial teeth, and that the same appearances as regards the translucent zone, thickening and swelling of the tubes and fibrils, and discoloration, are found, as in caries of natural living teeth; moreover, these authors found almost precisely the same changes occurring in teeth made from hippopotamus ivory. They attribute the translucency to a chemical solution of the calcareous salts, which near the termination of the tubes is washed out; deeper in, however, and in contact with the alkaline fluids of the tubes, the salts are precipitated as calcareous grains. The thickening and swelling of the tubes and fibrils is due to the decalcification of the tube walls, and to the presence of the fungus growth "leptothrix buccalis."

This fungus, which is plentifully found in tartar and about the necks of the teeth, is an active agent in the decay of the teeth. In fact, Leber and Rottenstein are of the opinion that after the enamel is penetrated by acids, or by mechanical injury, the fungus penetrates the dentinal tubuli, where it rapidly proliferates, destroys the fibrils and enlarges the tubes. They claim that after a lodgment upon the dentine is effected, even where it is not previously softened by acids, leptothrix rapidly destroys the tissue. Prof. Wedl, on the other hand, while admitting that leptothrix

hastens the destruction of the dentine, considers the action of acids the more active cause, leptothrix not attacking any portion of the dentine until it is first softened by caries and deprived of life.

The appearance of leptothrix is very well shown by Leber and Rottenstein and by Wedl. On the surface it resembles short, straight filaments. Mr. J. Tomes, in 1848, in his "Dental Physiology and Surgery," speaks of the presence of fungus growths in caries of the teeth, and describes one as "consisting of straight, stiff fibres or threads, so small that the structure cannot be seen. * * * They look, with the lower powers of the microscope, much as ordinary mould does to the naked eye." This answers very well as a description of *leptothrix filaments.* These filaments are seldom found in the dentinal tubuli; here the fungus presents a granular appearance, and is called *leptothrix matrix—elements* or *grains.* Softened dentine will be found full of these grains, which can readily be distinguished under the microscope. Leber and Rottenstein have also shown that the action of a dilute acid and iodine upon leptothrix gives a violent reaction.

The leading observers, with perhaps the exception of Neuman, Hertz, and Magitot, who ascribed the changes in advance of decay, in the dentinal tubuli, to a vital process, have accepted chemical action in connection with leptothrix as sufficient to produce these changes. Tomes, in the last edition of his "Surgery," says: "Inasmuch as no characteristic appearances can be found to distinguish caries as occurring in living from that attacking dead teeth, it seems that the hypothesis of vital action in any way modifying the disease must be abandoned in toto."

Still there are vital changes, an increased activity of the odontoblasts, occurring in teeth which are the subject of caries or other irritating causes, which is manifested by the formation of secondary dentine, which in many cases is so formed as to protect the pulp from invasion by the disease. The new formations are readily distinguished under the microscope. (Plate VIII.) They are not necessarily adherent to the walls of the pulp cavity, but often occur as small roundish granules in the pulp tissue. Sometimes they present a series of laminations about a common centre. They are well described by Wedl.

Several interesting cases of repair of fractures of the teeth are described by Wedl, and plates given, showing the nature of the

tissue of repair. He shows this to be almost entirely composed of dentine and osteo-dentine, developed from the tooth pulp; the part taken by the cement being only secondary.

Of the manner in which teeth of replantation become firm, Mr. A. Coleman, in a paper read before the Odontological Society of Great Britain, in 1870, states that examination of a superior molar which had been extracted and replaced, and was again removed at the end of thirty days, showed a dense fibro-cellular tissue, which was adherent to the dentine, and apparently projected into it. The dentine in the immediate vicinity of this new tissue seemed to have lost its distinctive character. Alluding to the tissue he says: "Appearances seemed to point to its belonging more to the tooth than to the surrounding structures," but adds, "it seems more easy to suppose that it had originated from the periosteum of the socket, and had become, by absorption of the tooth and a dovetailing into its substance, firmly attached to it, although all appearance of such attachment was lost." Mr. Coleman, and also Prof. Wedl, refer to the experiment of Dr. Mitscherlich, who removed an incisor tooth from a dog's skull and placed it in the alveolus of a living dog.* After an interval of six weeks the dog was killed and the carotids injected. Examination of the tooth showed it to be firmly attached to its socket. He found that new formations of osseous tissue had grown into the cavities and depressions on the root of the tooth. He believed the new growth was developed from the lining membrane of the socket, which first caused absorption of portions of the root, and having projected itself into the cavities thus made, it became ossified. A section of a living tooth which was replanted, became firm, and was worn four years, showed, under the microscope, a new formation of cementum over the original. From this we would infer that, under certain conditions, new growths from the membrane of the root also may be the means of fastening teeth of replantation. (Plate IX.) The new tissue, however, is more liable to absorption, causing loosening and loss of the replanted tooth, which we know is sooner or later the usual result.

The nature of the membrane, which Nasmyth discovered could be raised, by the use of an acid, from the crowns of unworn teeth, has been the subject of some discussion. The view held by Köl-

* This was transplantation of a dead tooth, and should be distinguished from replantation.

liker is, that after the complete calcification of the enamel cells, a secretion occurs which covers the entire surface and forms a protecting layer. Prof. Rolleston, in a paper read before the Odontological Society of Great Britain, 1871, ascribes its origin to the imperfectly calcified ends of the enamel cells, which become hardened or cornified. Waldeyer states it to be the cornified cells of the external epithelium of the enamel organ. He says that after treating it with a solution of nitrate of silver the epithelial cells may readily be seen. Mr. J. Tomes supposes it to be, not a product of the enamel, but of the cementum. He gives instances in which the cement extended over the enamel and into the fissures upon the crown. Prof. Wedl also supports this view, and gives an illustration of a molar tooth over which an enormous quantity of cement has grown. Mr. C. S. Tomes, in an article in the "Quarterly Journal of Microscopical Science," October, 1872, gives the result of his later investigations. He found the cement which fills the fissures of the enamel to be continuous with the *cuticula dentis*, and by the aid of an acid the whole could be removed, including the thicker portions containing the lacunal cells. (Plate VII.) As the membrane raised in this manner presented the same appearances upon the root of the tooth, and was continuous with it, he concluded it to be that thin layer of tissue which is in contact with the last formed cement, and which lies between the cement and the soft tissues. He says, "on the border of perfectly calcified structures there exists a thin stratum of tissue which presents marked differences from that which lies on either side of it; one of the manifestations of such difference being that great indestructibility which enables us to isolate it by the use of acids. Nasmyth's membrane appears to belong to this class of structures." Mr. Tomes' paper contains many strong arguments, and does more to settle the discussion in reference to the nature of Nasmyth's membrane than anything previously presented upon the subject.

DESCRIPTION OF PLATE I.

Longitudinal section of the jaw of a human embryo, showing tooth germ. The dentinal germ is seen in the shape of a papilla. The fold of epithelium is seen dipping down, the two layers separated over the papilla, forming the enamel germ, organ, which presents a darker appearance, bounded above by the external and below by the internal epithelium. In cutting the section an accidental space was formed between the dentinal and the enamel germs.

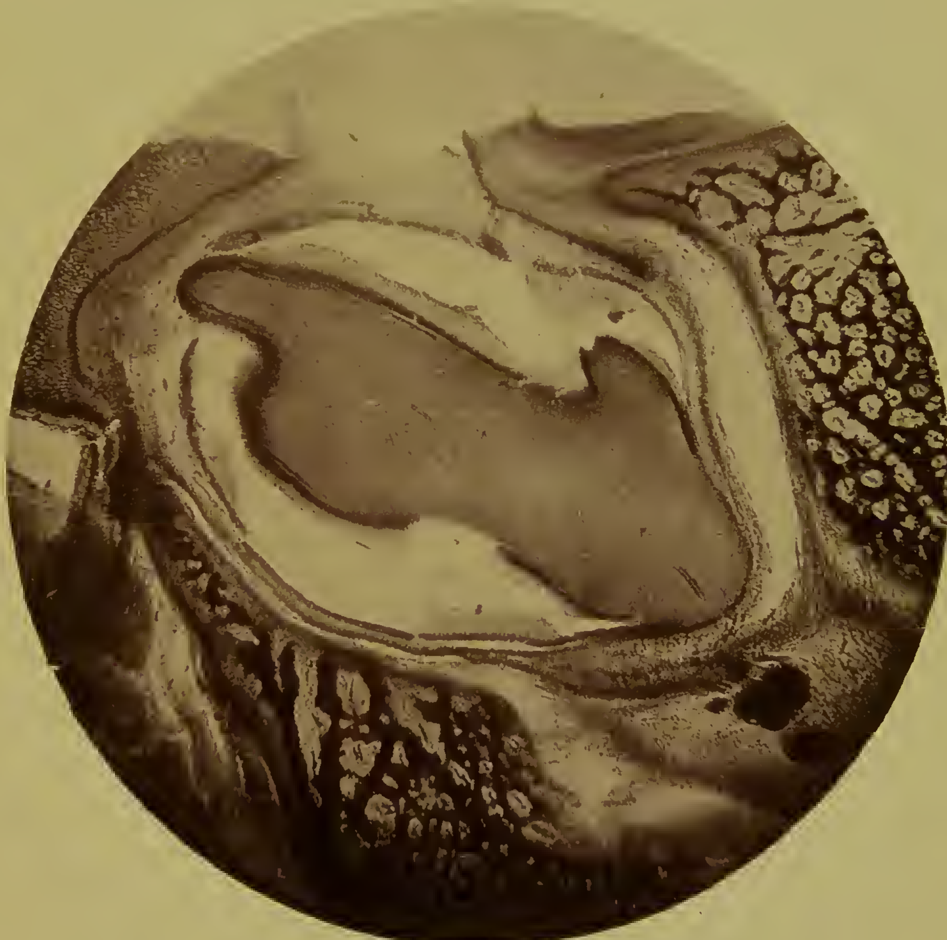
Magnified 100 diameters. ¼ inch objective.

1-100 of inch.

DESCRIPTION OF PLATE II.

Transverse section of the jaw of a fœtal calf, showing tooth germ. The dentinal germ has been distorted, and the enamel organ torn, in making the section. Some of the vessels may be seen in the dentinal germ; the dark line which bounds it is the developing odontoblasts internally, and the internal epithelium of the enamel organ externally. The lighter tissue beyond is the stellate reticular tissue, or, gelatinous layer, beyond which is the external epithelium; then comes the tooth sac of connective tissue, and the osseous trabeculæ of the alveolus.

Magnified 12 diameters. 1½ inch objective.



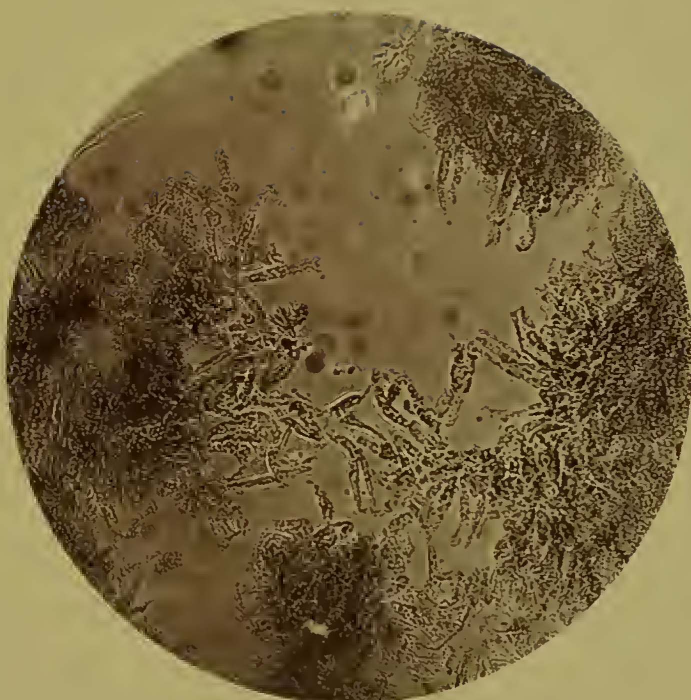
DESCRIPTION OF PLATE III.

A portion of the enamel organ from the tooth germ of a fœtal calf.

The enamel cells contain numerous nuclei.

Magnified 260 diameters. 1-10 inch objective.

1-100 of inch.

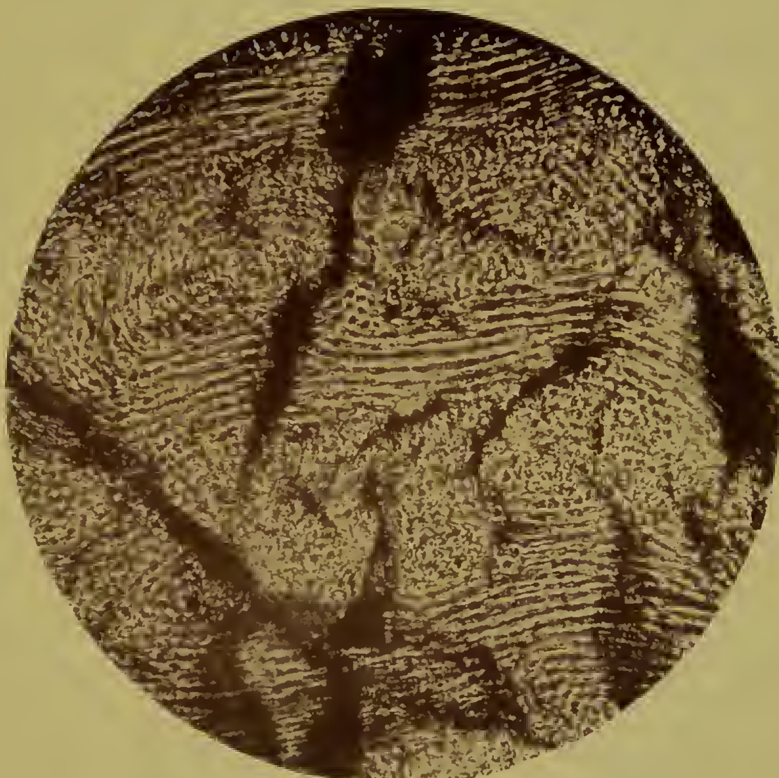


DESCRIPTION OF PLATE IV.

Section of enamel from the tooth of a dog. The dark places in the picture are caused by cracks in the section. Enamel prisms are seen longitudinally and transversely, in alternate bands. In those cut across transversely the roundish and hexagonal shapes may be seen. The shape of the prisms being determined by the amount of pressure to which the cells are subjected at the time of their calcification.

Magnified 260 diameters. 1-10 inch objective.

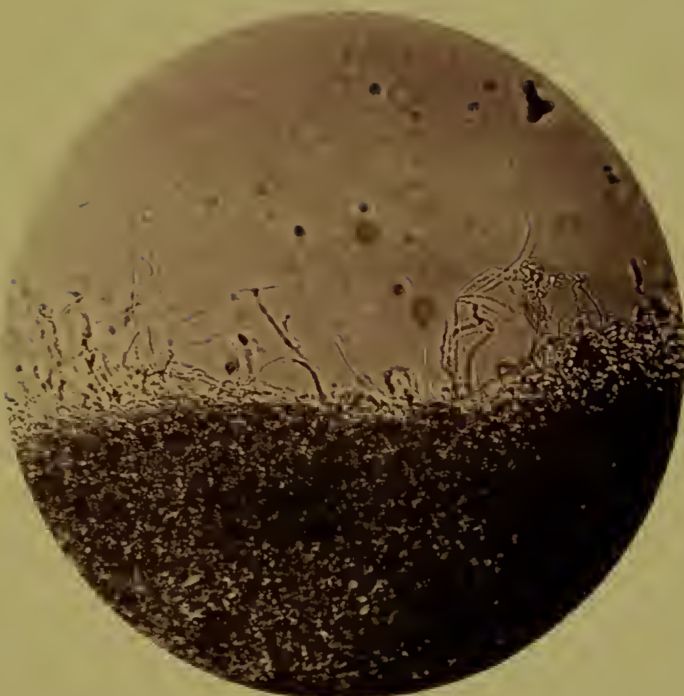
1-100 of inch.



DESCRIPTION OF PLATE V.

A portion of the root pulp of a molar. A freshly-extracted six-year molar, was cracked in a vice and placed in very dilute chromic acid (1-25 of 1 per cent.) for about an hour. On carefully removing the pulp from its cavity, the fibrils were drawn out from the dentinal tubes. Some of the fibrils show branches.

1-100 of inch.



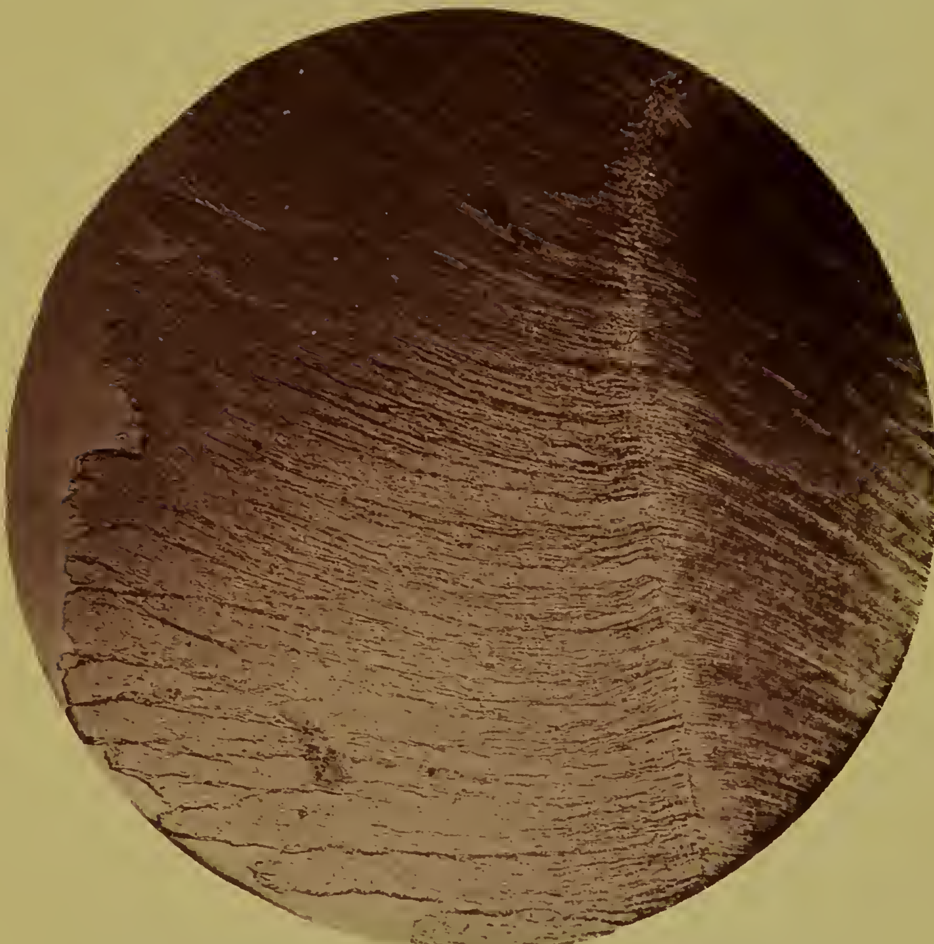
DESCRIPTION OF PLATE VI.

Section showing the penetration of dentinal tubes into the enamel.

The enamel with its fractured edge is seen at the left. At the right of the lighter boundary line is the dentine; tubes may be traced across this line in great numbers.

Magnified 100 diameters. ¼ inch objective.

1-100 of inch.



DESCRIPTION OF PLATE VII.

Section of a tooth showing faulty dentine, containing interglobular spaces.

The fainter spots toward the bottom of the picture are areolar markings. At the upper part, the enamel is seen with a fissure in it extending almost to the dentine; in the fissure, which is bordered by the "*cuticula dentis*," is seen, somewhat out of focus, a lacunal cell.

Magnified 112 diameters. ¼ inch objective.

1-100 of inch.

DESCRIPTION OF PLATE VIII.

Section of a superior central incisor. The right of the plate is toward the cutting margin; a small piece of the enamel is seen at the right hand upper margin of the plate. The uneven margins above and below show the walls of cavities of decay. The dentinal tubes are faintly seen in portions of the section; in other places they are obliterated. The reddish yellow color, which in the section of the tooth bounds the caries, also contributes to the darker appearance of these portions of the picture. Internal to this, and taking the shape of the former pulp cavity of the tooth, is a lighter tissue, the new formation, secondary dentine, the dentinal tubes of which are seen to be very irregularly disposed. The clear space at the left of the secondary dentine is the present pulp cavity. It is evident the pulp would have been exposed by the caries upon the upper portion were it not for the new formation.

Magnified 12 diameters. 1½ inch objective.

DESCRIPTION OF PLATE IX.

Section of the root of a replanted molar which was worn four years. The original layer of cement is distinctly seen as a light band, about a quarter of an inch wide, covering the dentine. External to this is a thick portion, nearly an inch wide, containing many lacunæ, and which is covered in part by another layer of a homogeneous and more transparent tissue. The dentinal tubes are well shown, and at the line of union of the dentine and cement may be seen the layer of finely granular, calcareous substance, which is usually found between the two tissues.

Magnified 100 diameters. ¼ inch objective.

1-100 of inch.